

## **Modeling & Simulation to Support C4ISR Acquisition and Transformation**

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### **Abstract**

Recently, a C4ISR Information Superiority Modeling & Simulation Master Plan (IS M&S MP) was issued by the Office of the Secretary of Defense (OSD) addressing the application of M&S to all functional areas associated with C4ISR (e.g., training, support to operations, acquisition) (Reference 1). In the area of acquisition, the C4ISR IS M&S MP called for the following actions: recommend and outline methods for providing improved M&S support to C4ISR acquisition; and provide recommendations of desirable policy changes and initiatives, along with metrics.

To implement those actions, a workshop was convened on 2 – 4 April 2002 under the sponsorship of the Office of the Assistant Secretary of Defense (C3I); the Director, Interoperability, Undersecretary of Defense (Acquisition, Technology, & Logistics); and the Director, Defense Modeling & Simulation Office (DMSO). Forty four subject matter experts from government, industry, and academia were assembled to address the subject.

The participants were organized into breakout groups to address C4ISR acquisition by system type (sensors, communications, C2/information processing) and systems-of-systems. In addition, a synthesis panel was convened to identify and summarize the similarities and differences in the findings and recommendations of the other breakout groups. To initiate the deliberations, the breakout groups were provided with a strawman list of M&S capability objectives to support

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C4ISR acquisition. For each of the major phases in the Department of Defense Directive 5000 on the acquisition of systems (Reference 2), the breakout groups used the strawman list of M&S capability objectives to identify and prioritize key M&S needs (i.e., the cases where critical M&S capability objectives could not be satisfied by the year 2007). Subsequently, each breakout group looked across the high priority needs identified in each phase of the acquisition process and formulated options to ameliorate the most critical of the M&S needs. The synthesis panel completed the deliberations by identifying overall, critical M&S needs and proposed investment options.

This paper summarizes the highest priority M&S needs that were identified to support the acquisition and transformation of C4ISR systems over the next five years. It is anticipated that the findings and recommendations from this workshop will drive the Department of Defense's investment in M&S to support the acquisition and transformation of C4ISR systems.

## **A. Introduction**

This paper is divided into five sections. The first section, the Context, describes the background for the workshop, identifies the goal, objectives, and scope of the activity. The second section sets the stage for the deliberations of the Panel by describing briefly how the C4ISR acquisition problem has changed since the end of the Cold War. The third section summarizes the insights and challenges that were derived from the remarks of the individuals that spoke during the introductory plenary session. These individuals can be aggregated into three categories: the sponsors of the workshop, representatives that described key institutional products, and Service representatives that discussed major initiatives in the area of M&S environments to support the acquisition of C4ISR. The fourth section establishes a framework for M&S to support the acquisition and transformation of C4ISR and embeds the major findings of the individual panels in that framework. That gives rise to insights on the similarities and differences in the panels' findings and recommendations. The report concludes with a Summary that describes what the workshop accomplished and residual challenges that remain to be addressed.

## **B. Context**

The underlying rationale for this workshop emerged from the recently released Information Superiority Modeling & Simulation Master Plan (IS M&S MP) (Reference 1). That plan addresses the application of M&S to all functional areas (e.g., training, support to operations, acquisition). Consistent with those interests, the goal of the workshop was to provide input to an investment plan for M&S to support the acquisition and transformation of C4ISR systems.

In order to support that goal, this paper addresses three objectives. First it captures relevant insights from the initial plenary presentations. Second, it identifies and summarizes the similarities and differences in the findings and recommendations of the workshop break-out groups. Finally, it summarizes the highest priority M&S needs that emerged from the workshop.

Although the workshop had relatively broad goals and objectives, it is important to highlight key areas that it did not address. First, it did not analyze the M&S needs associated with pre-acquisition activities (e.g., requirements analyses). These activities are outside the responsibility

of the sponsors of this workshop. In addition, the workshop did not address systems that transcended the control of the Department of Defense (DoD) or the Intelligence Community (IC). Consequently, it did not address the issues associated with C4ISR systems that include inter-agency mission/systems (e.g., the systems of the Federal Emergency Management Agency, Department of Justice) even though these systems are likely to be of increasing interest in the evolving mission of homeland security. In addition, it did not address specifically the issues associated with coalition/alliance operations. These are significant shortcomings that should be addressed in future workshops.

Consistent with these goals, objectives, and scope, the workshop employed the following approach. To establish a common framework, the workshop began with a plenary session that featured presentations from the workshop sponsors, briefings on key institutional products and processes, and presentations on major Service initiatives. Subsequently, the participants were divided into several break-out groups: single system panels (i.e., sensors, communications, command and control/information processing) and a system-of-systems panel. In addition, a synthesis panel was established to provide a broad, cross-cutting perspective on the subject.

At the outset of the break-out phase of the workshop, the individual panels were requested to begin with strawman M&S capability objectives and refine them (e.g., add or modify elements of the list). By comparing these capability objectives to projected capabilities for each phase in the acquisition process (in the 2007 timeframe), the panels were to identify residual needs and then to select the highest priority needs. Subsequently, the three to five highest priority needs, overall, were to be culled out and potential solutions provided.

### C. Nature of the C4ISR Acquisition Problem

This section of the paper briefly characterizes the nature of the evolving C4ISR acquisition process. It describes the new DoD acquisition context and associated DoD C4ISR acquisition challenges.

Old	New
• Well understood threat	• New and uncertain threats
• Established scenarios/operations	• Broad range of missions
• DOD focus	• National, coalition perspective
• Evolutionary capability	• Revolutionary capability
• Force-on-force	• Info/Effects-based outcome
• System-on-system advantage	• System-of-Systems advantage
• Requirements derived from deficiencies	• Exploration/Learning

Table 1. A New DOD Acquisition Context

Today's acquirers find themselves in a new national security context. Table 1 highlights some of the dramatic shifts that have occurred since the end of the Cold War. Having the Soviet Union as the single dominant adversary over a protracted period provided a sustained focus for intelligence gatherers and force planners so that they could refine U.S. understanding of many aspects of Soviet capability and behavior. This is in stark contrast to the "New World Disorder"

in which a broad range of varied and uncertain threats have made it difficult to anticipate issues and focus intelligence resources appropriately.

As a consequence of the Soviet focus, a relatively few scenarios and types of operations were sufficient for assessment and planning. Today the U.S. is faced with a broad set of operations and missions that include homeland security, peace keeping, coercive operations, small-scale contingencies, and major theater conflicts.

With the exception of the NATO allies, DoD was mainly concerned with operations that involved only the four Services. Many operations today require a much larger contingent of participants, including numerous non-NATO allies, various national government organizations, International Organizations (IOs), and Non-governmental Organizations (NGOs).

Until now, war fighting capability has evolved incrementally with the addition of each new weapon system. However, information technology and precision weaponry has the potential of changing the nature of warfare in revolutionary ways.

In the past, the key to success was believed to be determined by who could bring to bear overwhelming force. Today, the goal is becoming one of exploiting information about U.S. adversaries to apply the minimum force in order to achieve specific effects, consistent with national policy.

Advantage was often measured in platform-centric terms (e.g., who had the best tank, ship, or plane). Today, when the sensors, C2, and weapons are networked together in a system-of-systems, they promise significant advantage through increased agility and discriminate application.

Finally, the stable, evolutionary environment in which requirements are relatively well understood have given way to a period of experimentation and learning necessary to understand how to exploit rapidly emerging technologies and new concepts in order to maintain a competitive advantage. Taken together, these shifts add up to a fundamentally different national security context within which today's acquirers must function.

Old	New
<ul style="list-style-type: none"><li>• Threat based</li></ul>	<ul style="list-style-type: none"><li>• Capability based</li></ul>
<ul style="list-style-type: none"><li>• Refining established systems</li></ul>	<ul style="list-style-type: none"><li>• Exploring new possibilities</li></ul>
<ul style="list-style-type: none"><li>• Benefits of new capabilities</li></ul>	<ul style="list-style-type: none"><li>• Understanding fundamentals</li></ul>
<ul style="list-style-type: none"><li>• Firepower-centric</li></ul>	<ul style="list-style-type: none"><li>• Speed-centric</li></ul>
<ul style="list-style-type: none"><li>• Acquiring force structure</li></ul>	<ul style="list-style-type: none"><li>• Mission capability packages (e.g., DOTML-PF)</li></ul>
<ul style="list-style-type: none"><li>• Collection of <i>ad hoc</i> issues</li></ul>	<ul style="list-style-type: none"><li>• Hierarchy of related issues</li></ul>
<ul style="list-style-type: none"><li>• Tractable focus</li></ul>	<ul style="list-style-type: none"><li>• Exploding complexity</li></ul>

Table 2. New DOD C4ISR Acquisition Challenges

Shifts in the national security context have resulted in major changes in the challenges faced by teams of individuals that seek to acquire effective C4ISR systems rapidly and efficiently. Some of the key changes are highlighted in Table 2.

In the old context, acquirers could focus on means of countering a specific threat. Today they must address capabilities that can be used in an agile manner to deal with a range of threats. Similarly, because of the stability of the threat and the evolutionary nature of military capability, acquirers used to depend upon established operational concepts and capabilities. This contrasts with the current challenge where acquirers must cope with completely new war fighting concepts like distributed C2 for the nonlinear battlespace.

In the past, acquirers could focus on the benefits of adding a new C4ISR system to the force mix. Today, they must understand the fundamentals associated with networking the force or sharing information through a common operational picture. In addition, assessments used to be focused on force mix/structure issues. Today, assessments must address new mission capability packages, including all the dimensions of doctrine, organization, training, materiel, leadership & education, personnel, and facilities (DOTML-PF). Previously, acquirers often focused on issues in isolation (e.g., for communications systems, maximizing bandwidth for specified cost). Today there is a need for a systematic multi-level assessment of a comprehensive set of related issues in a system-of-systems context. Finally, the expanded dimensionality reflected in the above factors combined with the increase in the number of players translates into significant growth in problem complexity.

#### **D. Plenary Insights, Challenges**

This third section of the paper summarizes the insights and challenges that were derived from the presentations during the initial plenary session. The plenary session began with presentations by the workshop sponsors or their representatives: Director, Interoperability, Undersecretary of Defense (Acquisition, Technology, & Logistics); Assistant Secretary of Defense (Command, Control, Communications, and Intelligence); and Director, Defense Modeling & Simulation Office. They were followed by individuals who described and discussed key institutional products and processes: the IS M&S MP and Department of Defense Directive (DoDD) 5000. The plenary concluded with presentations discussing innovations that the Services are pursuing in the area of M&S to support the acquisition and transformation of C4ISR systems: the United States Air Force (USAF) Joint Synthetic Battlespace (JSB), the United States Navy (USN) Collaborative Engineering Environment, and the United States Army (USA) evolving Future Combat System (FCS) and the Joint Virtual Battlespace (JVB).

Over all, a common perspective emerged from the remarks of the sponsors and their representatives. All see M&S as critical to their organization's mission effectiveness. With respect to systems-of-systems, all saw it as a wave of the future which pose new M&S challenges for the community.

The presentation on the IS M&S MP emphasized its four major goals. These include:

- Assess the value of information superiority;
- Enhance the integration of M&S with real C4ISR systems;

- Develop M&S that reflect the decisionmaking and behavior of Blue and Red force commanders; and
  - Improve M&S for acquisition and transformation.
- Clearly, it is this latter goal that was the main focus of this workshop.

## The 5000 Model

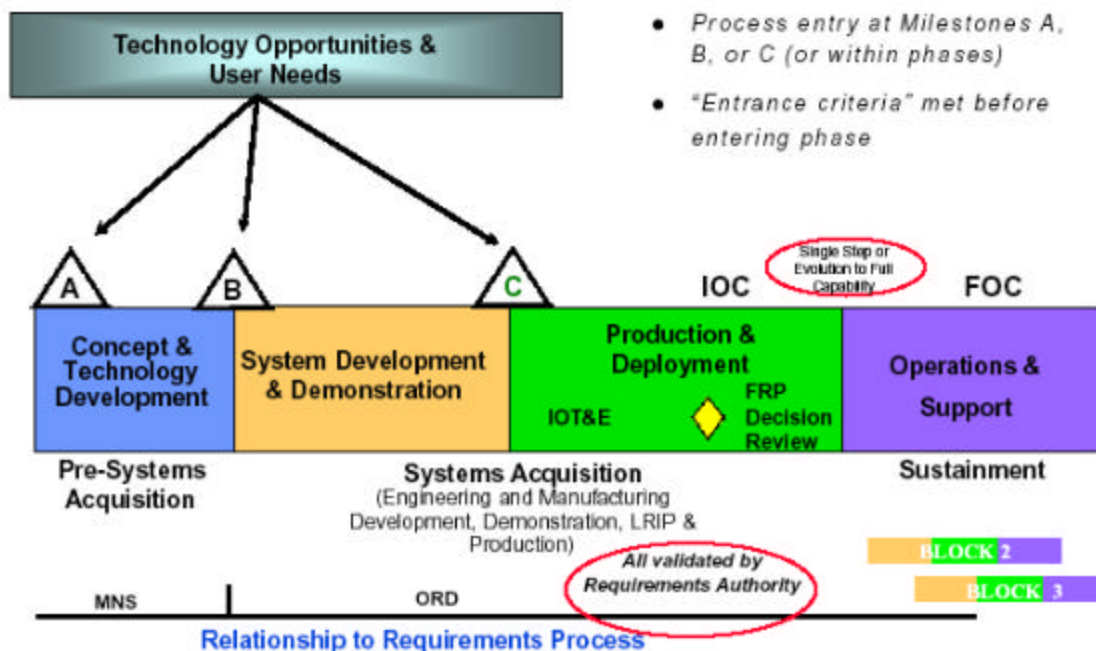


Figure 1. The 5000 Model

The presentation on DoD acquisition directives began by citing shortfalls in the existing acquisition process (e.g., it takes too long, costs too much, and is incompatible with modern subsystem cycle times). The opportunities offered by the acquisition model described in the latest version of DoDD 5000 were cited (see Figure 1). It was stressed that the model emphasizes the use of evolutionary acquisition, anticipating the need to inject new technology periodically (e.g., on the order of every eighteen months to keep pace with developments in the information systems sector of the commercial world). Several enhanced roles for M&S in support of this new model were identified. These included support to Analyses of Alternatives (AoAs) in Concept & Technology Development (CDT), Early Operational Assessments (EOAs) in System Development & Demonstration (SDD), and Operational Test & Evaluation (OT&E) in Production & Deployment (P&D).

However, it was acknowledged that there are several major residual challenges in DoDD 5000 that require future action, particularly in the guidance it provides on system-of-systems

acquisition. For example, since individual systems are acquired asynchronously, how do you do “full system demonstration” before the commitment to production or perform T&E of a full system-of-systems? In addition how do you deal with interoperability and supportability of a C4ISR system when multiple configurations are deployed, simultaneously? This latter issue is of particular concern to the US Army that must deal with the simultaneous fielding of large numbers of legacy, interim, and objective systems.

In the final segment of the plenary, representatives from the three Services described key initiatives. The Electronic Systems Command, USAF, is developing a JSB to support the future acquisition and integration of C4ISR-weapon systems-of-systems. This effort has pursued a “top down” approach”, systematically addressing the dimensions of leadership, policy, process, technology, and resources. To take advantage of the extensive investment in M&S environments that have been made, this approach strongly emphasizes Service/industry collaboration. Two residual issues were highlighted. First, today’s M&S capabilities do not adequately portray the complexity of the proposed USAF Global Strike Task Force. How can we enhance fidelity of M&S to ameliorate this shortfall? Second, the JSB staff participated in the April 2002 Joint Combat Identification Evaluation Team (JCIET) in order to acquire data to support JSB’s Verification and Validation (V&V) activities. However, it is not clear how one can systematically perform V&V of existing M&S and environments from the data that were collected. A question was also raised about who will own the JCIET data.

Second, the USN is developing a Naval Collaborative Engineering Environment to support Program Executive Officers (PEOs) and Program Managers (PMs) in meeting the Service’s integration and interoperability requirements. They have adopted a framework for integrated system evolution that emphasizes the separation of data and a suite of multi-functional tools to support the initial phase of acquisition (e.g., mission capability packages supported by Operational Requirement Documents, Analyses of Alternatives). Using a “best of breed” philosophy, they have assembled tools to support processes such as mission analysis (e.g., Navy Simulation System), architectural representation (e.g., Rational Rose), requirements analysis (e.g., DOOR), and functional analysis (e.g., CORE). Among the residual issues are the configuration control and management of the data base, the expansion of the tool set to meet emerging needs, and the evolution of the Collaborative Engineering Environment to support later stages of the acquisition.

Finally, the USA completed the Service perspectives by describing current thoughts on the C4ISR-weapon system mix for the proposed FCS and the tools that are evolving to support the acquisition of that capability. In the latter area, they are creating an arena to evaluate future system concepts drawing on the capabilities developed at the Joint Precision Strike Demonstration (JPSD) and the JVB. The philosophy is to integrate existing M&S tools and resources from a variety of sources (e.g., USA Research, Development, and Engineering Centers (RDECs), National Labs) and to augment them via a spiral build to address specific system acquisitions.

Two residual issues were highlighted for FCS. First, the need for enhanced human performance modeling was emphasized, particularly at the commander/staff level. In addition, concern was raised about the ability of current tools to address future system concepts. In particular, the

challenges associated with modeling future sensor management concepts and overall communications networking were identified.

Looking across the presentations by the three Services, it is noteworthy that cross-Service collaboration on their activities is ongoing and increasing. Since each Service has employed a different, but complementary approach, to the issue, such collaboration has the potential to enhance the quality of each Service's environments and to minimize duplication of effort.

## **E. Panel Findings and Recommendations**

This section of the paper addresses the break-out panels' findings and recommendations. It begins by identifying and discussing insights that were raised in the areas of systems-of-systems and cultural barriers. It then establishes a synthesizing framework to capture, compare, and contrast the findings and recommendations of the workshop panels.

During the course of the workshop numerous discussions occurred about the challenges associated with acquiring systems-of-systems. It was observed that in the absence of a system-of-systems context, we tend to maximize system parameters vice mission effectiveness. For example, the communications panel observed that if no system-of-system context is available, the tendency is to maximize bandwidth, at a given cost, vice acquire communications to support overall force effectiveness needs. Consistent with this observation, the single system break-out panels inexorably found themselves addressing system-of-systems issues.

However, as the system-of-systems panel noted, it is important to recognize that there is a *spectrum* of systems-of-systems, each with their own challenges. To illustrate this point, note that there are at least three broad classes of systems-of-systems:

- Planned and managed systems-of-systems. Examples include the USA's FCS and the efforts of the Missile Defense Agency (MDA). In fact, these two cases have appreciable differences due to variations in program control and funding.
- Oversight of *ad hoc* systems-of-systems. As an example, the USN has established the Distributed Engineering Plant (DEP) to ensure that *ad hoc* mixes of assembled systems are mutually supportive and interoperable prior to going to sea.
- *Ad hoc* systems-of-systems. This is representative of the vast number of cases that confront us. Thus, we often are strongly challenged when we attempt to assemble and deploy a system-of-systems to meet time urgent operational needs.

These observations led to the following conclusion. The image of the blind men and the elephant has often been used to convey the confusion that ensues when "stovepiped" entities ineffectively communicate in an endeavor that requires close coordination. That image has been particularly apt for the system acquisition process where many different functional communities participate (e.g., concept developers, operational users, system developers, testers, trainers, maintainers), with different perspectives, and limited communication.

However, that image may be misleading as we conceptualize future acquisitions. We can convey the need to change the image by observing that we have bad news and worse news. The bad news is that the participants in the acquisition process are still "blind". Even though there have

been efforts to create Integrated Product Teams to enhance communications among the functional participants in an acquisition, they have achieved only marginal success (due in part to their failure to share and evolve key tools and data).

The worse news is that the “elephant” has become a “herd of elephants”! As we realize that the real challenge is to acquire systems-of-systems, we find that we have distributed teams of “blind men”, clustered around individual “elephants”, who can neither communicate effectively across functions or across systems. This is a first order issue which will require changes in culture, organization, education and training, processes, tools, and infrastructure.

In addition, it must be understood that future systems-of-systems will require us to cope with many alternative perspectives reflecting differing institutional cultures. In this workshop, differences were apparent in two dimensions: across the Service participants and between the DoD and IC communities. In the latter case, there were distinctive differences voiced with respect to classification issues. Ultimately, as we deal with the full inter-agency, international problem, those cultural barriers will be even more pronounced. Although this workshop did not focus on the cultural dimension of the problem, it is important to acknowledge its existence and to recognize that a successful solution must confront it.

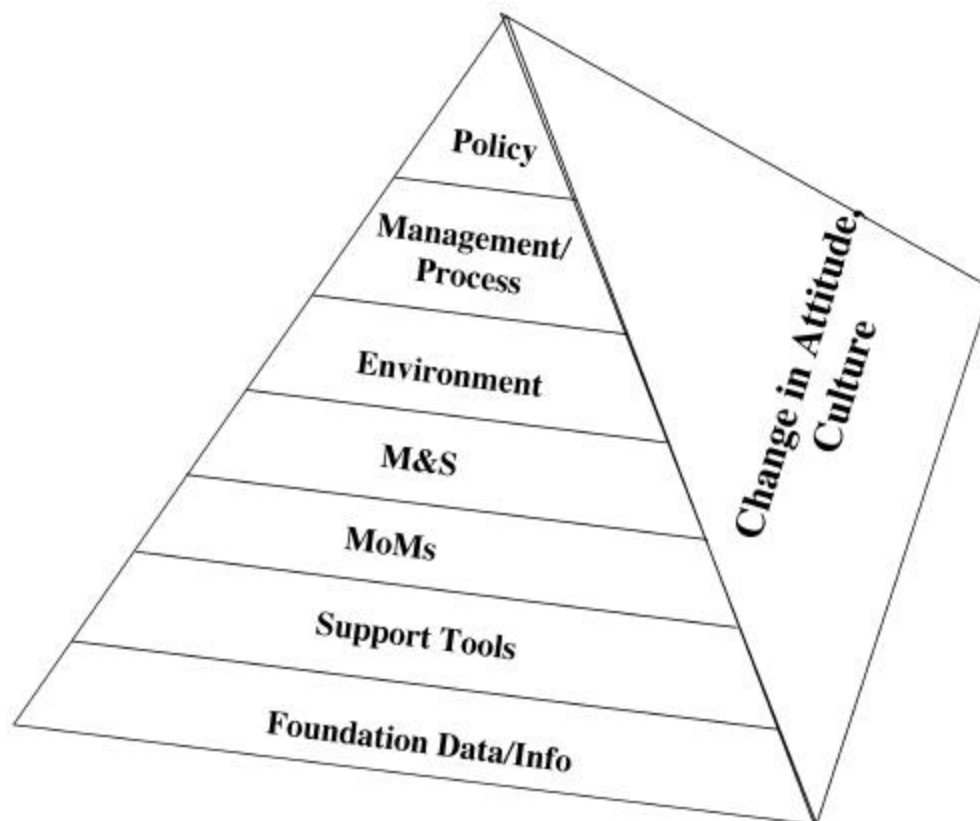


Figure 2. Framework for Synthesis

Figure 2 provides a framework that was created to identify a set of categories that must be addressed by the acquisition community. It is concluded that if future C4ISR assessments are to be planned and conducted successfully in a dynamic environment *and* supported effectively by the M&S community, we must consistently address *all* of these factors in a balanced way. The backdrop for these factors is set by the *cultures* of the many communities that must participate in future C4ISR acquisitions. To remind us of the importance of the cultural dimension, one facet of the pyramid is labeled “change in attitude, culture”.

The base of the framework rests on foundation data and information. It subsumes repositories of critically needed information (e.g., environmental data). Building on that foundation are a set of broadly needed support tools. These include readily tailorable and reusable scenarios. Resting on these support tools, are sets of hierarchies of measures of merit (MoMs). These range from measures of C4ISR system performance (e.g., bandwidth of communications systems) to overall measures of campaign effectiveness (e.g., the time required to halt an invading army). Once the MoMs have been identified, it serves to clarify the individual M&S modules that are needed to evaluate the measures of interest. These M&S modules are then federated into environments that enable the acquirer to assess the measures efficiently over the requisite set of scenarios and assumptions. In order to develop and employ these environments, it is necessary to have sound management and associated processes. Finally, at the apex of the pyramid, are sound policies that guide the acquirer in applying M&S appropriately in the acquisition process.

Category/Panel	Comms	Sensors	C2/IP	S-O-S
Policy			○	○
Mgt/Process				○
Environments	○	○	○	○
M&S	○	○	○	○
MoMs	○	○	○	
Support Tools	○	○		○
Foundation Data/Info	○	○	○	○

Figure 3. Synthesis Framework: High Priority Needs

Each of the panels was requested to identify their *highest* priority needs, across all of the phases of the acquisition process. Figure 3 indicates the categories for those highest priority needs, by panel.

Even at this level of abstraction, an interesting trend appears. Two of the single system panels (sensors and communications) focused on the categories associated with the lower part of the pyramid (i.e., environments down to foundation data/information). Although the details of their needs varied to reflect their domains of interest, they tended to be consistent in tone and emphasis. Conversely, the C2/IP and system-of-systems panels, which tended to be broader in scope, reflected increased interest and concern about issues of policy, management, and process.

The material that follows, briefly summarizes the major needs that were identified, by category, and discusses the similarities and differences among the findings of the individual panels.

In the area of policy, two broad needs were identified. First, the system-of-systems panel called for a revisit of DoDD 5000 to ensure that it addressed critical system-of-systems issues adequately. For example, there was a need to address mission capabilities based decision-making vice individual system decision making. Second, there is a need to develop and provide government/contractor access to authoritative M&S and repositories for data, algorithms, joint scenarios, and synthetic natural environments. This access might be implemented by the SIPRnet and NIPRnet.

In the area of management/process, the system-of-systems panel called out the need to derive insights from system-of-systems events (e.g., exercises, experiments). In order to do so, there is a need for sufficient funding, authority, and responsibility to capture and exploit important data from these events.

Each of the panels identified major needs in the area of acquisition environments. The broadest need was articulated by the system-of-systems panel which called out the need for secure, distributed, scalable, responsive, standards-based, collaborative engineering environments. Specific attributes of these environments were identified by the other panels. For example, the C2 panel called out the need for these environments to be interoperable with those of industry and to evolve throughout the acquisition process. The remaining panels noted the need for these environments to be able to interface with other systems, M&S, humans in the loop, and hardware in the loop.

Each of the panels identified major needs in the area of M&S. At a macro-level, the system-of-systems panel called out the need for a reference model for alternative levels of interest (e.g., system, function, mission, campaign) that would help identify key M&S capabilities and shortfalls. Several of the other panels identified specific M&S that were needed. These included communications models appropriate for system of systems level analyses and network operations support, planning, and training; high level M&S that could support quick turn-around assessments for sensor trade studies; the ability to model information infrastructures; and M&S that featured better representations of decision making processes in C2.

There was general agreement that a hierarchy of MoMs is needed that would support assessments of the impact of C4ISR systems on mission effectiveness. In the discussion, it was noted that NATO's evolving Code of Best Practice for C2 Assessment is an excellent point of departure to pursue the development of those MoMs (Reference 3).

Several panels identified the need for support tools to enhance the ease of use and responsiveness of M&S. In particular, it was stated that there is a need for reusable, tailorable scenarios; a joint library with an extensive scenario set (including Blue force laydowns); and common environmental representations.

Finally, several of the panels identified the need for key foundation data and information. From a system-of-systems perspective, it was observed that there is a need for synchronization points for past, current, and future system performance data. In addition, needs were identified for common standards for inputs to drive models and the identification of architectural data to link architectural representations to executable simulations.

## **F. Summary**

This final section of the report identifies what we were able to achieve at the workshop and several residual challenges that remain to be addressed. It identifies a balanced set of initiatives that should be pursued to ameliorate the major high priority needs that were identified by the break-out groups. The section concludes with a brief statement of the “bottom line”.

The workshop was characterized by three major achievements. First, it provided a forum at which effective interchange among government, industry, and academia was achieved. Second, it served to clarify the nature of the problem associated with the M&S needed to support the acquisition and transformation of C4ISR systems. In particular, a substantial number of key needs were identified and their relative significance was assessed. Finally, the workshop identified a set of the most critical needs, documented them, and formulated options to ameliorate them.

Due to time limitations, the participants were directed to focus their attention on a relatively small set of highest priority needs. Each panel identified a much larger set of needs, many of which warrant additional attention. Those needs should be re-examined in subsequent workshops.

In addition, the workshop was scoped to restrict attention to the phases of the acquisition process and activities limited to DoD and the IC. As noted above, it is important to identify and address the needs associated with pre-acquisition activities (e.g., the requirements process). In addition, US military operations are increasingly dependent on inter-agency participants and multinational/coalition partners. Further assessments are required to identify the M&S needs that their participation requires.

In order to support the acquisition and transformation of C4ISR systems, it will be necessary to undertake a *balanced* set of initiatives. This requires actions in *each* of the categories that comprise the framework pyramid.

The items cited below reflect the highest priority needs identified by the workshop participants. It is believed that they constitute a necessary but not sufficient set of actions to redress the many needs that confront the C4ISR acquisition community.

From a policy perspective, it is recommended strongly that DoDD 5000 be revised to clarify the challenging problems associated with the acquisition of the several varieties of systems-of-systems.

From a management/policy perspective, it is recommended that steps be taken to focus the acquisition process on achieving enhanced mission capability. This implies taking steps to ensure that one acquires the “right thing” as well as acquiring the “thing right”.

From an environment perspective, it is important to acquire collaborative environments that enable acquirers to explore interface issues with other systems, hardware in the loop, software in the loop, and humans in the loop.

From a M&S perspective, it is important to take inventory of our M&S strengths and weaknesses (through a reference model) and to take steps to redress those weaknesses (e.g., enhance the representation of decision making).

From a support tool perspective, there is a need to create common environmental representations and to assemble libraries of tailorable, reusable scenarios.

Finally, from the perspective of foundation data/information, it is important to provide easily accessible, broadly available data on architectures, systems performance, and organizational behavior.

This workshop has a clear bottom line. The workshop participants are in broad agreement that to support the transformation of the C4ISR system, all acquisitions must be conducted in a system-of-systems context. Further, to acquire a system-of-systems, it will require a strong, integrated M&S capability. If the needs identified in this workshop are addressed in a balanced way, we will have taken a major step towards realizing those goals.

## **G. References**

1. C4ISR Information Superiority Modeling & Simulation Master Plan (IS M&S MP), OASD(C3I), March 2002
2. Department of Defense Directive (DoDD) 5000, OSD, September 2001
3. NATO Code of Best Practice (COBP) on the Assessment of C2, RTO Technical Report 9, AC/323(SAS)TP/4 (Hull, Que.: Communication Group, Inc., March 1999)